Using GIS and Spatial Statistics to Examine Patterns of Crowding on Lake George

By NANCY A. CONNELLY, TOMMY L. BROWN and TIMOTHY P. HOLMES

Abstract

The Lake George Park Commission recently undertook a large planning study to assist them in fulfilling their legislative mission of "providing reasonable public access to Lake George without congestion, overcrowding, or safety hazards." The results reported here, directed at assessing Lake George users' perceptions of crowding on the Lake, are but a small part of the larger study. We studied five types of recreational users on Lake George (lakeshore property owners, annual motorboat permit holders, temporary motorboat permit holders, beach users, and commercial dock owners). We used geographic information systems (GIS) and spatial statistics to identify zones of varying levels of crowding based on users' perceptions. On a questionnaire mailed in summer and fall of 2005, respondents indicated on a map the areas they used and the areas they perceived as crowded. We found some disparity between use and perceptions of crowding in various portions of the lake, but these variables were moderately correlated. Using the spatial statistic of Local Moran's I, three areas were identified for all types of users as being significantly correlated with either high or low levels of crowding. Displaying maps produced using GIS allows for much easier interpretation of spatial data, and the use of spatial statistics can confirm (or deny) perceived spatial patterns. We believe these results will be useful for future planning and management of Lake George, and we think this technique can be successfully applied to a variety of recreational situations in the Adirondacks and elsewhere.

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Introduction

Lake George, a beautiful lake located within the Adirondack Park in upstate New York, is 32 miles long and up to three miles wide. It is easily accessible from the interstate highway connecting New York City and Montreal, Canada. The Lake George region provides a variety of water-related recreational opportunities. Motorboaters, sailboaters, canoeists, swimmers, and fishermen all enjoy the lake, which is noted for its clarity. In recent years, however, moderately heavy recreational use of the lake has been accompanied by concern for the preservation of the lake's beauty and water quality (Martin and Borgos 2002). Development pressure, especially for seasonal-use housing, has increased almost twofold in the past 30 years (Rath 2005). Development has occurred primarily along the shore of the southern half of the lake, but access is possible from many points around the lake.

Lake George Park Commission (LGPC) is the state agency charged with management of the lake. Its legislative mission is to "provide reasonable public access to Lake George without congestion, overcrowding, or safety hazards." The LGPC recently undertook a large planning study to assist the commission in fulfilling its legislative mission. The results reported here, directed at assessing Lake George users' perceptions of crowding on the lake, are but a small part of the larger study (Holmes et al. 2006). The goal of the work reported on here was to identify zones of varying levels of crowding based on users' perceptions. This type of analysis could be particularly valuable to the LGPC in deciding whether sufficient need exists to manage different zones of the lake for varying levels of use or to identify "hot spots" of crowding where safety is an issue and policy changes may be needed.

Past research on the issue of crowding has been extensive (see for example review articles by Shelby et al. 1989; Kuentzel and Heberlein 1992; or more recently Manning 1999), but there has been little focus on mapping the spatial aspects of perceptions of crowding. Peters and Dawson (2004), for example, used line thicknesses on a map to show concentrations of use, but did not equate that with user perceptions of crowding. Therefore the specific objectives for the research reported herein are to

- compare recreationist-identified areas of use with their perceptions of crowded areas,
- use spatial statistics to establish zones of high or low crowding based on recreationists' perceptions,
- examine sociodemographic and use characteristics that are related to perceptions of crowding, and
- examine whether a spatial dimension exists to different types of users' perceptions of crowding.

Methods

A mail survey was developed and sent to five types of Lake George users in the summer and fall of 2005. The questionnaire asked about use of the lake for recreation, perceptions of potential water-based recreation issues or problems, and identification of specific areas of crowding.

Survey Audiences and Sample Selection

Five types of users were identified as potential survey audiences. Below is a description of each group and how a sample of that group was obtained.

Residential dock owners. Any residential landowner with a dock on Lake George must obtain a permit from the LGPC. Since almost all shoreline owners have docks, this group essentially represents residential lakeshore property owners. We drew a systematic sample of 600 names from the 2005 list of 2,380 permittees.

Annual boat permit holders. Members of this group purchased a permit from the LGPC allowing them to use motorboats (10 hp. or more) or larger sailboats (18 ft. or more) on Lake George during the 2005 season. In drawing our sample from this group, we excluded residential dock owners. Thus, annual boat permit holders represent annual users who do not own land along the lake. We drew a systematic sample of 600 names from the 2005 list of 10,713 permittees.

Temporary boat permit holders. Members of this group purchased a permit from the LGPC allowing them to use motorboats (10 hp. or more) or larger sailboats (18 ft. or more) on Lake George for a day or a week during the 2005 season. We drew a systematic sample of 599 names from the 2005 list of 5,732 temporary permit holders.

Beach users. This group represents non–motorboat users of 13 beaches along the Lake George shoreline during the 2005 season. They could be using nonmotorized boats such as canoes or kayaks, but most were observed engaged in beach-related activities. A sample of 446 users was obtained over the course of the season by field interviewers stationed at each of the beaches.

Commercial dock owners. This group consists mostly of marina and hotel owners. Surveys were sent to all 166 commercial dock owners on the LGPC list as of August 2005.

Questionnaire Development and Implementation

The mail questionnaire topics relevant to this analysis included recreational use of the lake, perceptions of crowding and related issues such as noise, and sociodemographic characteristics of users. The center page of the questionnaire contained a map of Lake George, on which respondents were asked to write a letter "A" where they accessed the lake, to circle the area(s) where they spent the majority of their time recreating, and to lightly shade the areas they thought were "routinely so congested that it interfered with their enjoyment of the Lake." (This wording then becomes our definition of crowding.) Commercial dock owners were not asked about their own experiences, but rather what they thought their clientele did or perceived. Thus, data from this group may be less accurate because it is a mental compilation of the aggregate experiences of their clientele, rather than the direct observations and perceptions obtained from the other groups.

The temporary boat permit holders' and beach users' surveys were mailed out over the course of the summer of 2005 as names became available. This strategy allowed for better recall of the trip experience than would have been obtained if we waited until the end of the season. We anticipated that the other groups would use Lake George over the entire summer season, so mailings went out to them right after Labor Day. Up to three reminder letters were sent to nonrespondents over the course of the month following the first mailing to try to encourage their participation in the study, as advocated by Dillman (2000).

Data Entry and Analysis

Data from the questionnaires except for the map were entered on the computer using standard procedures and analyzed using SPSS, a computer software package designed to analyze social science data. Chi-square tests were used to test for significant differences in the percentages of respondents in different user groups thinking some part of Lake George was crowded. Correlation analysis was used to test for significant differences in perceived crowding by zone between user groups.

The map on each questionnaire was overlaid with a Mylar sheet dividing the lake into the 43 management zones used by the LGPC. Coding was done (presence, absence) to indicate which zones were accessed and used by respondents and which zones respondents thought were crowded. Almost all respondents indicated a location where they accessed the lake or spent the majority of their time (96% and 95%, respectively), therefore we assumed that if they did not mark any areas as being crowded, they were indicating they did not feel any areas were crowded. Data were converted to a geographic information systems (GIS) file showing the percent of respondents in each zone who used the zone and/or thought it was crowded. Data are presented as a map of Lake George using ArcGIS Version 9.1. GeoDA Version 0.9.5-i5 was used to calculate the spatial statistics of Moran's I and Local Moran's I (LISA) using first order neighbors with Queen Contiguity (Spatial Analysis Lab, no date). These statistics test for similarities in user perceptions of crowding between neighboring management zones on the map of Lake George.

Each user group returned a sufficient number of questionnaires to permit analysis by group. In order to also present an overall picture of the views of Lake George users, we weighted the individual responses such that each group was represented in proportion to its contribution to the population of Lake George users. Weighting was not needed to make comparisons between user groups.

Results

Response Rates

Of the 2,411 questionnaires mailed, 65 were undeliverable and 1,199 were returned usable, for an adjusted response rate of 51%. Response was lowest among commercial dock owners (40%) and highest among residential dock owners (60%). No checks for nonresponse bias were done because it was impossible to ask questions using the maps on the telephone (the usual method chosen for assessing nonresponse bias). Based on past research (Connelly et al. 2003),

nonrespondents are typically less interested in the topic being studied. In this case, nonrespondents *may* have used the lake less and *may* be less concerned about lake management issues.

Recreational Use

Respondents made use of all parts of Lake George in 2005, but the middle sections around Shelving Rock and Diamond Point and the northern area around Hague received heaviest use (Fig. 1). Access frequency, as depicted by the boat size shown in each zone in Figure 1, indicates a wide distribution along the southern and eastern shores, but in the north and west access was limited primarily to a few locations where boat launch ramps exist.

General Perceptions of Crowding-Related Issues

Over 90% of respondents were satisfied with their 2005 Lake George recreational experience. Primary sources of dissatisfaction were crowding-related issues (e.g., too many boaters, making too much noise, not following the rules, creating boat wakes and speeding). Over half (53%) of all respondents thought noise from personal watercraft was a problem in 2005; 46% thought noise from other boats was a problem. Over half (52%) thought unsafe operation of boats, and one-third (34%) thought crowding at boat anchorages was a problem.

About one-third (31%) of respondents reported at least one zone as being so congested that it interfered with their enjoyment of the lake. Most respondents reported between one and four zones as being crowded (Fig. 2). A clear visual distinction between the northern and southern ends can be seen from Figure 2, the southern end being perceived as more crowded. Moran's I, used to test for spatial autocorrelation across the whole lake, showed a significant spatial autocorrelation of 0.74 (p = 0.001), indicating that neighboring zones were positively correlated with each other—i.e., if one zone was perceived as crowded, it was likely that its neighbors would be perceived the same way. Local Moran's I, a more precise test used to indicate specific areas with statistical significance, indicated three areas where neighboring zones were significantly related to each other (Fig. 3). The northern zone, shown with darker shading, indicates a cluster of zones where the percent perceiving the area as crowded was low. Two areas in the south were a lighter shade, indicating the percent perceiving an area to be crowded was high, with a white area in between showing no significant relationships. One might call this area a transition zone of moderate or variable crowding.

Comparison of Figure 2 with Figure 1 shows some differences between the areas people used and those they thought were crowded. Most

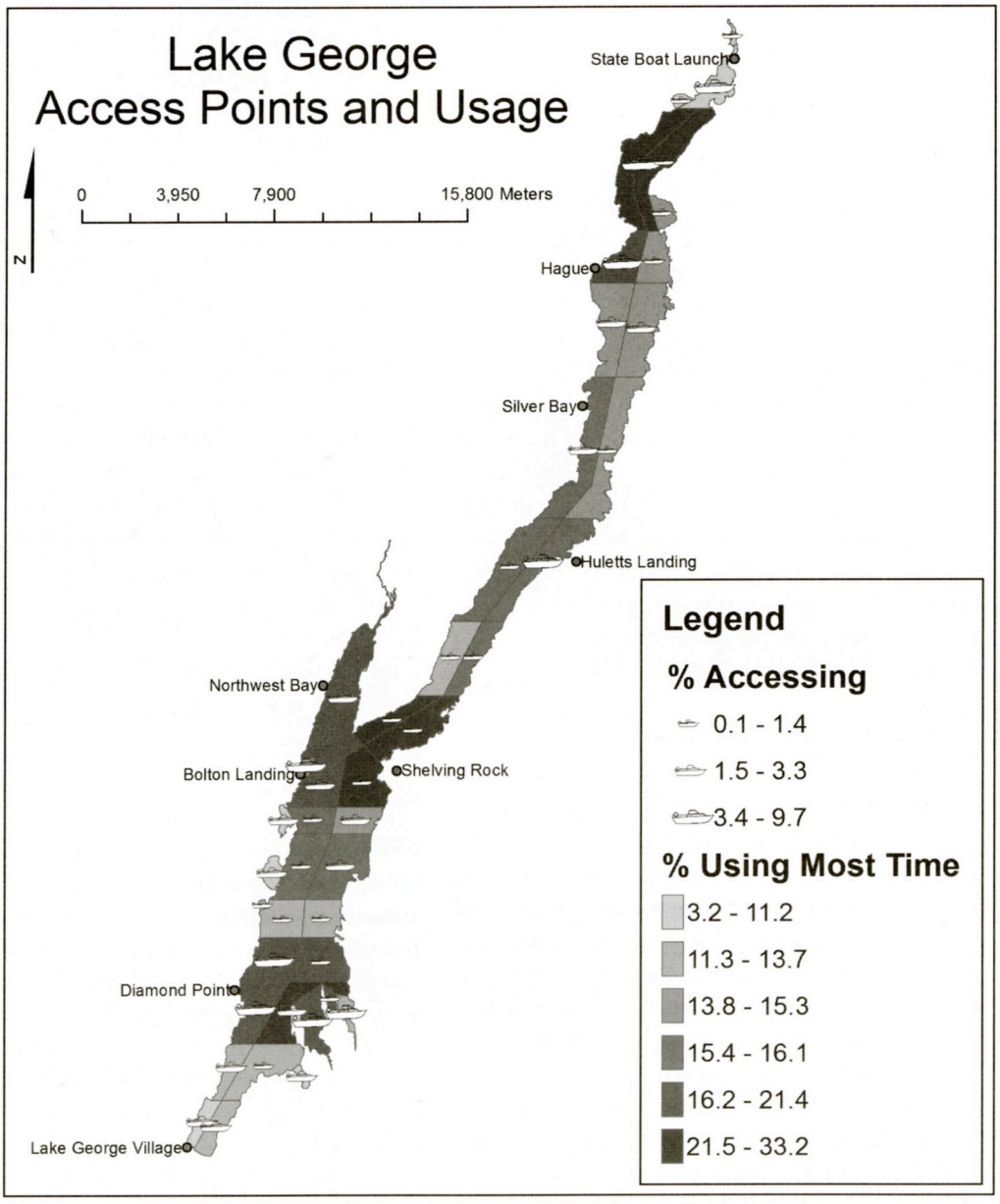

Figure 1. *Percent of respondents accessing Lake George in 2005 from each zone and the percent indicating they spent the majority of their time in each zone.*

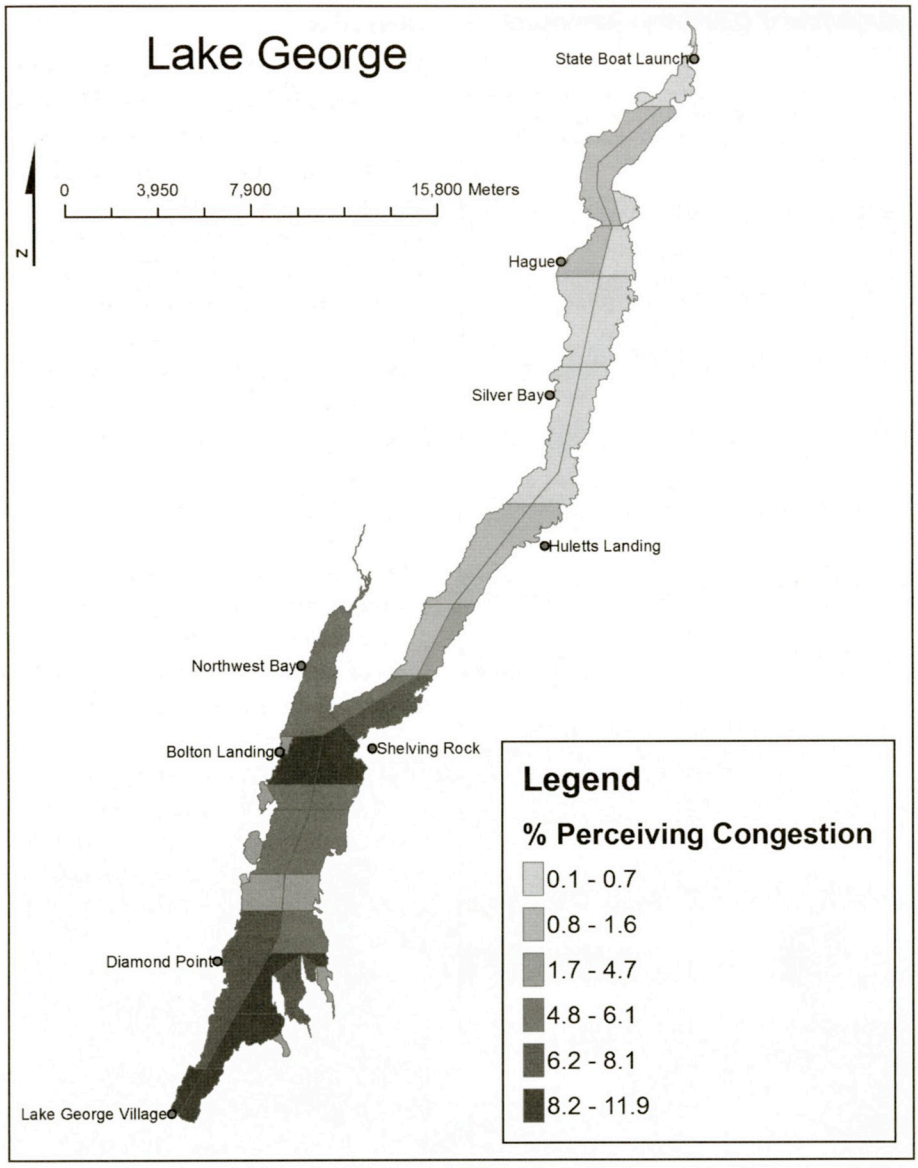

Figure 2. *Percent of respondents perceiving each zone as routinely so congested that it interfered with their enjoyment of Lake George in 2005.*

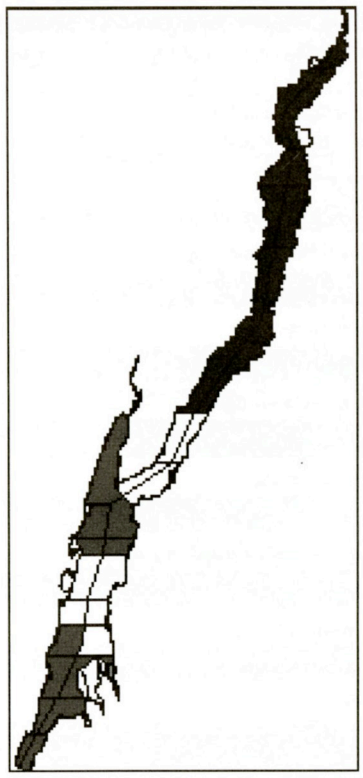

Figure 3. *Significantly correlated zones of congestion on Lake George as calculated using Local Moran's I for all survey respondents. (Note: Lighter shading indicates neighboring zones with significantly correlated high levels of congestion; darker shading indicates significantly low levels of congestion. In white zones there are no significant relationships with neighboring zones.)*

notable is the southern end of the lake, where people perceived crowding but their usage alone would not predict crowding. However, the overall correlation between respondent-identified areas of use and crowding was significant (r = 0.460, p = 0.002).

User Characteristics and Crowding

Perceptions of crowding differed based on sociodemographic and use characteristics (Table 1). Respondents who spent more time around Lake George, either by virtue of being seasonal residents, owning shoreline property, having an annual boating permit, or indicating more years of experience, were more likely to indicate at least one zone that they perceived to be crowded. Temporary boat permit holders and day-use visitors had negative correlations with crowding, indicating their general lack of perception of a problem. Current residence area, as measured by community size, was not related to the likelihood that a respondent perceived an area of Lake George as being crowded.

Examination of the spatial distribution of the five user groups' perceptions of crowding using correlation analysis and visual inspection of Local Moran's I significance maps indicates that groups identify the same areas as being crowded (Table 2). The correlation between groups and which zones they perceived to be crowded was always above 0.75. Fewer members of some groups thought the lake was crowded, but those who perceived crowding identified the same areas. For example, more annual than temporary boat permit holders thought the lake was crowded (44% vs. 18%, Table 1), but the zones they identified as most or least crowded were the same, as illustrated by the high correlation between the two groups in Table 2 and visual inspection of Local Moran's I significance maps.

Table 1. *Percent of respondents indicating some portion of Lake George was crowded, by sociodemographic and use characteristics*

Sociodemographic or Use Characteristic	Percent Indicating at Least One Zone Was Crowded
User group*	
Residential dock owners	36.6
Annual boat permit holders	44.1
Temporary boat permit holders	17.5
Beach users	17.2
Commercial dock owners	39.4
Local resident status*	
Year-round resident	37.6
Seasonal resident	35.2
Visitor or day-user	20.9
Years visited or lived in area*	
Less than 1 year to 29 years	24.1
30 or more years	37.6
Residence area	
Rural	31.5
Community fewer than 5,000 people	34.2
Community 5,000 to 24,999 people	30.8
City 25,000 to 100,000 people	28.5
City more than 100,000 people	30.9
Age	
18–53 years old	28.9
54 or more years old	33.3
Gender*	
Male	32.8
Female	26.5
Own powerboat*	35.3
Own nonmotorized boat*	41.1
Own personal watercraft*	27.1

* Statistically significant difference within sociodemographic or use characteristic in the percent indicating at least one zone was crowded using chi-square test at $p = 0.05$.

Table 2. *Correlation of user groups' perceptions of crowding by zone on Lake George*

User Groups	Residential Dock Owners Correlation (p-value)	Annual Boat Permit Holders	Temporary Boat Permit Holders	Beach Users
Annual boat permit holders	0.934 (<0.001)			
Temporary boat permit holders	0.862 (<0.001)	0.888 (<0.001)		
Beach users	0.758 (<0.001)	0.807 (<0.001)	0.788 (<0.001)	
Commercial dock owners	0.853 (<0.001)	0.902 (<0.001)	0.775 (<0.001)	0.823 (<0.001)

Discussion

The use of spatial statistics was helpful in identifying areas of the lake with both high and low perceived crowding and in defining transition areas. Local Moran's I showed neighboring zones where crowding was high in two sections of Lake George. The LGPC and others can examine these areas in more detail and consider whether management actions are needed to reduce crowding. Although not all user groups were equally likely to perceive crowding, they identified the same areas as being crowded. This degree of concurrence should ease the task of the LGPC in targeting specific areas of the lake for special consideration in future planning efforts.

We found some disparity between areas of use and perceptions of crowding across the lake, but there was a good correlation. We believe, as do others (Cole et al. 2005), that use estimates alone are insufficient for addressing issues of crowding. Therefore, our measure of perceptions of crowding contributes additional valuable information for planners.

This study, like others, found relationships between sociodemographic and use characteristics and perceptions of crowding (e.g., Kuentzel and Heberlein 2003). Those with more experience on the lake were more likely to perceive the lake as crowded.

GIS, and more recently spatial statistics, have become important tools for recreation planners (McNulty 2004). Displaying maps produced using GIS allows for much easier interpretation of spatial data, and the use of spatial statistics can confirm (or deny) perceived spatial patterns. The current application is the first to our knowledge in which perceptions of users have been mapped and analyzed to identify potential areas of crowding. We believe this technique can be successfully applied to a variety of recreational situations.

Acknowledgment

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Literature Cited

Cole, D., Manning, R., and Lime, D. 2005. Addressing visitor capacity of parks and rivers. *Parks & Recreation* (March): 8, 10, 12.

Connelly, N. A., Brown, T. L., and Decker, D. J. 2003. Factors affecting response rates to natural resource-focused mail surveys: Empirical evidence of declining rates over time. *Society and Natural Resources* 16: 541–549.

Dillman, D. A. 2000. *Mail and internet surveys: The tailored design method.* New York: John Wiley & Sons.

Holmes, T. P., Connelly, N. A., and Brown, T. L. 2006. *Lake George recreation study plan, 2005.* Lake George Park Commission (http://adirondackresearch.com/projects/lakegeorge).

Kuentzel, W. F., and Heberlein, T. A. 1992. Cognitive and behavioral adaptations to perceived crowding: A panel study of coping and displacement. *Journal of Leisure Research* 24: 377–393.

———. 2003. More visitors, less crowding: Change and stability of norms over time at the Apostle Islands. *Journal of Leisure Research* 35(4): 349–371.

Manning, R.E. 1999. *Studies in outdoor recreation: Search and research for satisfaction,* 2nd edition. Corvallis, OR: Oregon State University Press.

Martin, J. A., and Borgos, S. 2002. Lake George . . . "The Queen of American Lakes." *Adirondack Journal of Environmental Studies* 9(1): 21–26.

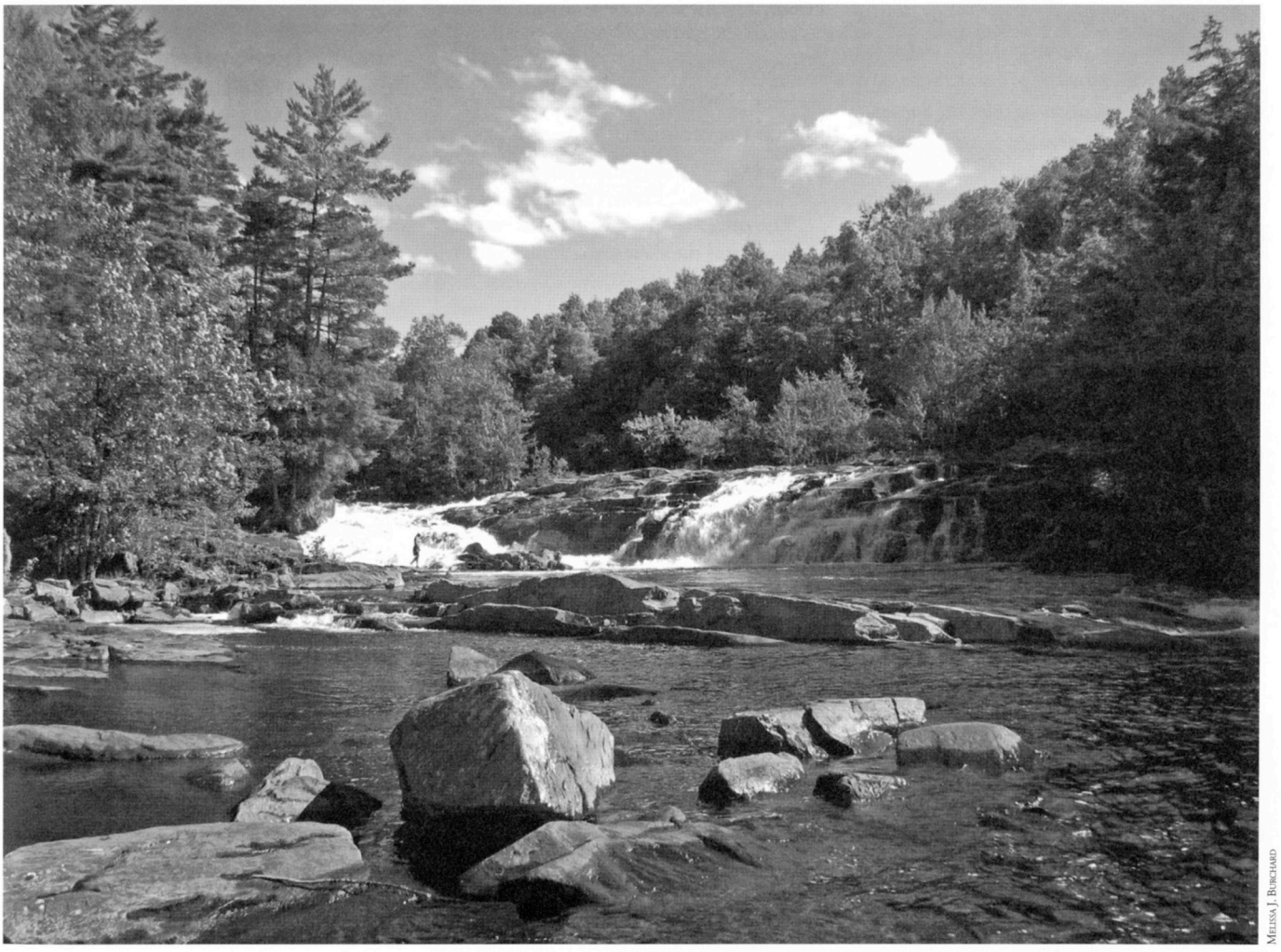
McNulty, S. A. 2004. Stitching together the patchwork quilt: Using GIS to assist the inventory portion of the Adirondack Forest Preserve Unit Management Planning Process. *Adirondack Journal of Environmental Studies* 11(1): 5–9.

Peters, N. E., and Dawson, C. P. 2004. Estimating visitor use and distribution in two Adirondack Wilderness Areas. *Proceedings of the 2004 Northeastern Recreation Research Symposium.* Gen. Tech. Rep. NE-326. Newtown Square, PA: U.S. Forest Service, Northeastern Research Station.

Rath, R. 2005. A shoreline community within the Blue Line: What has changed over time? *Adirondack Journal of Environmental Studies* 12(1): 20–24.

Shelby, B., Vaske, J. J., and Heberlein, T. A. 1989. Comparative analysis of crowding in multiple locations: Results from fifteen years of research. *Leisure Sciences* 11: 269–291.

Spatial Analysis Lab. No date. GeoDA—An introduction to spatial data analysis. University of Illinois. https://www.geoda.uiuc.edu/ (accessed 1/16/08).



MELISSA J. BURCHARD

One of the many waterfalls on the Raquette River visible along the 7.5-mile Stone Valley Loop Trail